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*Pediatric*

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**Abusive Head Trauma**

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*Pocket Atlas*

*Volume One*

*Traumatic Injuries*



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# *Pediatric*

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# Abusive Head Trauma

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# *Pocket Atlas*

*Volume One*

# *Traumatic Injuries*

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## FOREWORD

The best feature of this innovative approach to the evaluation of children who may be victims of abusive head trauma (AHT) is the thoughtful approach to features such as cerebral edema, several forms of intracranial bleeding, ophthalmologic concerns, and other important features while sifting through, sometimes extensive, differential diagnoses. The inclusion of discussions of findings like birth trauma, genetic and metabolic disorders, short falls, and other possible diagnoses (although usually extremely rare) that will be considered in some children is another excellent feature of this 2-volume pocket atlas.

A variety of images, either photographs or radiologic studies, are presented to inform the thinking of clinicians who often need quick access to information in order to perform a thorough evaluation in the shortest time possible. If a patient is stable, this book also allows for a quick, but in-depth review of results after an episode of AHT or one of the other diagnoses that must be considered in most cases.

The *Pediatric Abusive Head Trauma* 2-volume set also allows medical students and residents to have a concise reference to augment what is usually only a brief exposure to this important diagnosis. Brain injury is a serious and all-too-frequent cause of morbidity and mortality in children. This diagnosis will often be challenged in court, as perpetrators of the injury are frequently prosecuted. Consequently, not only is the material in the Atlas important for guiding the diagnostic evaluation but also serves as a reference for both the general pediatrician and the subspecialist who may present their opinions in a court case.

**Robert W. Block, MD, FAAP**

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## FOREWORD

Law enforcement faces many challenges during the investigation and prosecution of child abuse. Nonetheless, we as professionals seek justice through a search for the truth, found in the evidence obtained during an investigation and through interviews with witnesses and potential perpetrators. With abusive head trauma (AHT), the leading cause of injury and death in young children, being armed with a working knowledge of pediatric medicine and forensic methods enhances our initial response, evidence collection, and interviewing efforts. In addition, an investigator's ability to document a victim's presentation, symptoms, and medical history and incorporate them during a suspect's initial interview may yield critical information for other multidisciplinary professionals who are often involved in AHT cases.

The various chapters in the *Pediatric Abusive Head Trauma* series address topics relevant to law enforcement involved in child abuse investigations. In particular, the chapter on Biomechanics will increase one's understanding of the various types of head injuries and the effects of motion and force. This chapter expands on two areas significant during the early stages of an investigation: differentiating between abusive and accidental injuries and how/why the presentation of head trauma in children can be quite different from head injuries in adults. Familiarity with these areas allows law enforcement to gather a comprehensive history of an event and corroborate a caregiver's statements or challenge a possible perpetrator's initial account. The case studies, which will likely sound familiar to many experienced investigators, illustrate the most common social and environmental factors of AHT cases and provides investigative context for the medical findings in these cases. The section on medical mimics clarifies and demystifies the various conditions which can appear similar to traumatic head injuries. Since accurate and detailed timelines can be linchpins in these cases, understanding the differentiations between AHT and diseases or preexisting birth/accidental trauma can be critical to successful prosecution. Finally, the inclusion of color photographs, illustrations, and diagrams are beneficial, especially for nonmedical professionals, in that they visually demonstrate the associations between anatomy, biomechanics, injury presentation, and interpretation of tests results.

Successful child abuse investigations and prosecutions often depend upon law enforcement, social programs, and the medical community sharing information and valuable techniques. The significance of this collaboration is never more apparent than in cases of AHT, due to the frequency of its occurrence and the complexities surrounding diagnosis and mechanism. By providing a comprehensive resource

to improve recognition and responses to AHT, this 2-volume pocket atlas will be of particular assistance to law enforcement professionals who seek to integrate important medical aspects into their child abuse and child homicide investigations.

**Joy Lynn E. Shelton, BA<sup>1</sup>**

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<sup>1</sup>*Ms. Shelton, a Crime Analyst with the Federal Bureau of Investigation's (FBI), Behavioral Analysis Unit III - Crimes Against Children, has 15 years of experience in the investigation and analysis of violent crimes against children and has coauthored numerous articles on the topic of child homicide. This Foreword is being provided in an unofficial capacity and is not an endorsement by the FBI.*

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## FOREWORD

Two weeks into my career as child abuse prosecutor in a rural community, I was asked to try a termination of parental rights case. Suddenly, I was enmeshed in myriad legal and medical issues involving neglect, failure to thrive, excessive discipline, and more. I quickly realized that law school had not prepared me for any of this. Even more alarming, I quickly learned that most of my colleagues, including law enforcement officers, social workers, doctors, nurses, and psychologists were similarly inadequately trained in many aspects of child maltreatment.

The problem of inadequate training in child maltreatment is particularly pronounced in small, rural communities where, by necessity, every practitioner is a general practitioner. In the prosecutor's office where I worked, we didn't have "divisions" or "sections," we had me and my boss. Accordingly, we handled every crime in our county from speeding to murder. As a result, it was difficult to specialize in any particular area.

In order to survive, much less excel in cases of child abuse, I learned the value of books. In particular, I relied on concrete, practical treatises that helped me understand myriad aspects of child maltreatment and that would assist me in explaining complex issues to jurors and judges. Our rural community eventually gained national recognition for our work in addressing child abuse, and it was our reliance on quality, practical publications that made all the difference in the world.

As I travel around the country working with frontline child protection professionals from every state, I repeatedly hear the need for publications of value to practitioners. Accordingly, I am excited about the publication of the *Pediatric Abusive Head Trauma* series.

In the field of child protection, there is no area more complex than abusive head trauma nor any area that generates as much controversy. Unfortunately, many child protection professionals are poorly equipped to recognize actual indicators of abusive head trauma, as opposed to symptoms that merely mimic abuse. Equally concerning, some defense experts prey on the naïveté of child protection professionals, judges, and jurors and have assisted some child abusers in escaping justice.

Through a concrete, comprehensive analysis of all aspects of abusive head trauma, this book will be of immeasurable assistance to the field. Through understandable prose and invaluable charts, photographs, and pertinent citations, this book will advance our field by helping frontline professionals properly and thoroughly assess cases.

I am grateful to the thousands of child protection professionals who labor long hours on behalf of children in need. It is for you and the children you serve that this book was written. If the text that follows helps even one of you assist a single child, this writing will not have been in vain.

To that end, I invite you to turn the pages of this book and to turn a new chapter in the history of child protection.

**Victor I. Vieth**

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A Program of Gundersen Health System

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## PREFACE

Abusive head trauma (AHT) is among the most severe manifestations of child physical abuse, and it is a major cause of morbidity and mortality. Yet, even though it has been documented since the very first descriptions of child maltreatment—by Tardieu in the 19th century,<sup>1</sup> Caffey,<sup>2</sup> Silverman,<sup>3</sup> and Kempe<sup>4</sup> in the 20th—its clinical recognition is often delayed. Its pathogenic mechanism continues to be a source of debate, and it has many potential mimics.

Earlier clinical recognition of AHT and many topics of contention regarding its mechanisms, pathogenesis, and evolution over time could be eliminated by a thorough exposition of the facts. This book will, therefore, describe and illustrate multiple aspects of AHT. It is constructed to serve as a reference for medical, social service, law enforcement, investigative, and legal professionals regarding recognition, diagnosis, and treatment of traumatic injuries and medical mimics.

We hope that this 2-volume pocket atlas will provide readers with a broad perspective and clarify many of the points in question about this important topic.

**Lori Frasier, MD, FAAP**  
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**Francois Luyet, MD**

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## REVIEWS

*The Pediatric Abusive Head Trauma 2-volume set is a comprehensive review of the leading cause of physical abuse deaths in the United States today. It offers an in-depth evaluation of victim clinical presentation, usual physical examination, laboratory, and neuroradiologic findings, and outcomes. It also explores reasonable differential diagnoses and provides illustrative cases. This is an outstanding reference for child abuse pediatricians and for those professionals such as pediatric neurologists, child development specialists, and generalists who care for AHT survivors often afflicted with complex medical problems.*

**Debra Esernio-Jenssen, MD, FAAP**

Professor of Pediatrics  
Child Protection Team  
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*This text contains concise and up-to-date discussions of facets and controversial aspects of abusive head trauma (AHT). As an example, Dr. Spivack briefly and in a very understandable manner discusses the basics of AHT biomechanics and injury evolution. Chapters on injury types discuss the basic background, causation, and treatment of AHT injuries while also documenting related conditions and possible abuse mimics. Dr. Fingarson's chapter on hypoxic-ischemic injuries nicely discusses causes and the radiologic and clinical evolution of these injuries, accompanied by prototypic images. Real injuries, such as venous sinus thrombosis, which are often within the legal venue, inappropriately, proposed as causing head injury findings as an alternative to AHT are succinctly summarized by Dr. Siffermann, while noting the lack of evidence that sinus thrombosis causes subdural hemorrhage.*

*For a quick reference to multiple aspects of AHT, this book deserves a place on your bookshelf.*

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*Having been involved in child protection investigations and prosecutions for over 15 years, I can say that every serious unexplained injury of a child presents challenges to medical professionals, law enforcement, CPS, and courts. It is important that professionals in each of these domains have access to the most reliable information with which to meet these challenges.*

*Most lawyers and judges, and certainly most jurors, do not come into the courtroom with a particularly strong background in medical science. To an untrained person, the line between good science and junk science can be difficult to discern. To be effective, attorneys must be familiar enough with the science underlying medical evidence to be able to elicit the medical testimony in a way that is understandable and helpful to the listener.*

*Child protection investigations and litigation typically proceed at the accelerated pace necessitated by the critical need to protect children who are at risk of harm, and it is of the utmost importance for all involved to get it right. Betting it wrong means either leaving children in danger or, perhaps needlessly, disrupting custody and relationship between parent and child.*

*This book provides a valuable resource for Child Protective Services investigation staff and attorneys. Concise and authoritative, this book will assist the nonmedical professional in formulating the questions and avenues of inquiry that will help to get at the truth of situations which can involve complex fact patterns, conflicting witness statements, ostensibly unwitnessed events, and defense claims which mirror defense theories easily available on the Internet.*

**Zev Kianovsky**

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*Pediatric Abusive Head Trauma is an excellent resource that provides both superb visual depictions and discussions of traumatic head injuries. Case illustrations, detailed annotations, and a current reference lists make each chapter a treasure trove for clinicians, particularly for those who educate students, residents, and fellows. Multiple medical conditions that could be confused with abusive head trauma, such as birth trauma, disorders of coagulation, and genetic disorders, are included, which makes this 2-volume atlas an invaluable reference to use in exploring alternative hypotheses in both clinical care and courtroom settings.*

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# INTRODUCTION

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# INTRODUCTION

Dena Nazer, MD

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Abusive head trauma (AHT) refers to child physical abuse that results in injury to the head and its contents. Over the years, many terms have been used to describe AHT. These include inflicted pediatric neurotrauma, whiplash shaken infant syndrome, shaken baby syndrome, shaken impact syndrome, and nonaccidental head injury. In 2009, the American Academy of Pediatrics (AAP) Committee on Child Abuse and Neglect (COCAN) recommended using the term AHT to account for the multitude of primary and secondary injuries that result from abusive head trauma.<sup>1</sup> The term AHT encompasses various mechanisms of traumatic brain injury, including shaking without external impact, shaking with impact, and impact. The term AHT includes children beyond infancy in whom this syndrome has been documented.<sup>2</sup>

AHT is a leading cause of morbidity and mortality in infants and young children. It is the leading cause of death from trauma in children younger than 2 years. The true incidence, however, is unknown due to the variable inclusion criteria of AHT studies, and AHT being underreported and underrecognized.<sup>3,4</sup> Population-based studies from various authors provide surprisingly similar incidence of approximately 20/10 000 hospitalized children less than one year of age.<sup>4,5</sup> Infants, especially males with a mean age of 2 to 6 months are at highest risk for AHT.<sup>4,5</sup> Infants hospitalized as a result of AHT are a small subset of the infants who experience shaking as a form of discipline, as reported in parental surveys.<sup>3</sup> Most perpetrators of AHT are men, most commonly fathers, followed by boyfriends, female babysitters, and lastly, mothers.<sup>6</sup> Epidemiologically, being born to a young mother, multiple births, and being a noncaucasian infant are risk factors for being diagnosed with AHT.<sup>4,7</sup> The literature has recently cited evidence supporting the presence of cultural protective factors against child abuse for Hispanic children; however, there is no specific data regarding AHT for this ethnic group.<sup>8</sup>

## COMMON PRESENTATIONS

Infants who are victims or survivors of AHT have variable presentations depending on the type and severity of injury. They are more likely to present with a history of no trauma or minor trauma

compared to children with nonabusive head injuries.<sup>9</sup> Infants subsequently diagnosed with AHT may present with a sudden onset of clinical signs and symptoms attributed to an accidental household head injury, eg, falling off a couch. Rarely will a caregiver immediately give details of his or her abusive actions prior to the infant's clinical presentation and diagnosis of AHT.

AHT may be diagnosed by screening for occult trauma when a young child presents with a sentinel injury<sup>10</sup> such as a poorly explained fracture or a bruise. AHT may also be diagnosed (or missed) during the evaluation for other disease conditions that have similar clinical presentations, like seizure disorders or gastroenteritis. AHT is more likely to be missed when a child presents with less severe, nonspecific symptoms, eg, vomiting, irritability, and/or lethargy; with no external signs of trauma on physical examination, eg, the absence of facial or scalp soft tissue injuries; or is from a white, intact family.<sup>11</sup> AHT is less likely to be missed when the child presents with respiratory distress or seizures.<sup>11</sup>

## SUBTYPES

Vigorous, repetitive shaking is a common mechanism of AHT described by perpetrators.<sup>12</sup> However, AHT may result from a variety of mechanisms and traumatic forces, including acceleration/deceleration forces and/or blunt force trauma, penetrating trauma, and asphyxiation.<sup>13</sup>

## SIGNS AND SYMPTOMS OF AHT

Symptoms of AHT vary in part based on the severity of injury. Children may present with a variety of nonspecific symptoms or with severe alterations in consciousness or coma. Common symptoms include<sup>14</sup>:

- Vomiting
- Seizures
- Apnea or respiratory distress (breathing difficulty)
- Lethargy and/or irritability
- Poor feeding

## FEATURES

Children who are victims of AHT may have some characteristic features in their clinical history, physical examination, and/or the type of injuries. In this section, we will briefly describe these features.

### Medical history

A complete medical history should be obtained in all cases of suspected AHT. Essential details can be reviewed in **Table 1**. There are historical indicators of abuse in a child with head injuries, including<sup>14</sup>:

- No history of trauma

**Table 1. Medical History in Suspected AHT Cases****Detailed timeline of symptoms, including events prior to and after the onset of symptoms**

- Child's behavior prior to the trauma or onset of symptoms, eg, when was the child last seen acting normally?
- Detailed description of the trauma, eg, a fall, when provided:
  - Where and when the trauma occurred
  - Ear and/or eye witnesses
  - Child's position prior to trauma
  - Way in which the child fell, landed, or was impacted
  - Height of fall and type of landing surface
  - Child's behavior immediately following traumatic event
  - Caregiver's response to trauma

**Psychosocial history: risk factors associated with AHT**

- Single and/or young parents
- Unstable family situations
- Lower socioeconomic status
- Urban locations
- Previous reports to protective services, psychiatric diagnoses, family violence, and substance abuse in the caregiver
- Multiples (twins, triplets, etc)
- Prematurity and disability in the child

**Names of child's caregivers and their relationship to child****Birth, past medical history, and family medical history****Developmental abilities of the child, especially motor skills****Possible trigger for abuse, eg, crying, behavior, temperament, and toileting**

- History of low-impact trauma in the presence of persistent neurologic injury
- History of trauma that is inconsistent with the clinical findings
- History of trauma that is inconsistent with the child's development
- Changing or conflicting histories
- Injury blamed on a sibling, another child, or pet
- Injury blamed on home resuscitative efforts

### Physical Examination

Children with AHT typically have no external signs of trauma. Findings, however, that may raise suspicion of AHT and other inflicted injuries include:

- Signs of head impact injury, including subgaleal hemorrhages, head or facial contusions
- Trauma to the mouth and nose, eg, torn labial or lingual frenula, oronasal bleeding
- Any bruising in a nonambulatory child and patterned bruising at any age, eg, grip marks, bites

### Ocular Findings

A dilated indirect retinal examination by an experienced pediatric ophthalmologist is an essential part of the evaluation for AHT. Retinal hemorrhages are a common intraocular sign of AHT (**Figures 1**). Their absence, however, does not rule out AHT or any other form of abuse. Retinal findings need to be documented (number, type, and distribution) with detailed manual drawings and photodocumentation, if available.<sup>15</sup> Retinal hemorrhages appear to be the result of vitreoretinal traction and orbital injury.<sup>15</sup> The severity of retinal hemorrhages correlates with the severity of brain injury, with a higher prevalence of retinal hemorrhages in those who die from their injuries.<sup>16</sup> Retinal hemorrhages rarely result in long-term vision compromise; however, poor visual outcomes may result from secondary brain injury in the occipital lobe or direct injury or atrophy of the optic nerve.

### Intracranial Injuries

Subdural and subarachnoid hemorrhages are the most common intracranial injuries attributable to AHT (**Figures 2**). Their incidence is significantly higher in AHT as compared to accidental injury.<sup>17</sup> Subdural hemorrhage is the most common single lesion in AHT. Subdural hemorrhages as a result of AHT are usually thin, contouring over the cerebral convexities and into the interhemispheric fissure. Most subdural hemorrhages do not require surgical evacuation due to their small size; however, if large, they may cause mass effect.



Figure 1-a

**Figures 1-a and b.**  
*Funduscopy images of a 3-month-old child's retina demonstrating the presence of multiple retinal hemorrhages. (Courtesy of Carmelina Trimboli-Heidler.)*



Figure 1-b

Parenchymal brain injury is also associated with abuse and often has serious, even fatal, neurologic consequences.

### Fractures

Children presenting with skull fractures with no trauma history or a minor trauma history should be evaluated for AHT. The most common skull fractures in both abuse and nonabuse groups are linear parietal skull fractures.<sup>18</sup> The significance of complex skull fractures regarding the possibility of abuse varies between studies.<sup>18</sup> Except for skull, pelvic and facial fractures, bruising or swelling over the fracture site(s) is uncommon.<sup>19</sup>



*Figure 2-a*

**Figures 2-a and b.** Cerebral edema in a 2½-year-old abused child with apnea, lethargy, and extensive bruising.

**Figure 2-a.** Axial CT image demonstrates extensive and diffuse cerebral and cerebellar edema with loss of gray-white matter differentiation. There is effacement of the skull base cisterns with early dilation of the right temporal horn (arrow A). There are scattered areas of acute, hyperattenuating intracranial hemorrhage with the largest collection on the left tentorial leaflet (arrow B) and extending along the adjacent left cerebral hemisphere.



*Figure 2-b*

**Figure 2-b.** Axial CT image obtained more superiorly demonstrates acute posterior interhemispheric subdural hemorrhage (arrow). Extensive bilateral cerebral edema is present with loss of gray-white matter differentiation, midline shift, and effaced ventricles and sulci.

The most common fractures not involving the skull associated with AHT are rib fractures and metaphyseal fractures (classic metaphyseal lesions sometimes referred to as corner or bucket-handle fractures). Multiple rib fractures have the highest probability (71%) of being caused by abuse in the absence of a confirmed accidental mechanism.<sup>18</sup> Metaphyseal lesions are the most common long bone fracture type in fatal AHT.<sup>20</sup> Overall, multiple fractures are more common in abusive—compared to accidental—injury.<sup>18</sup>

## SUGGESTED EVALUATION

Evaluation of AHT includes the following:

- Detailed history from caregivers and any ear or eye witnesses.
- Complete physical examination with special attention to the head and neck, skin, and extremities.
- Dilated indirect ophthalmoscopic examination by an ophthalmologist.
- Laboratory testing<sup>21</sup>: In cases of intracranial hemorrhage, the child needs to be evaluated for the possibility of a bleeding disorder. The initial panel aims to detect disorders for which the probability of the condition resulting in intracranial hemorrhage is greater than 1 per 5 million.<sup>22</sup> The following tests should be performed: complete blood count with platelet count, prothrombin time, activated partial thromboplastin time, Factor VIII level, Factor IX level, and DIC panel (D-dimer and fibrinogen).<sup>22</sup> Liver function tests should be obtained to screen for occult abdominal trauma.
- Head imaging: All infants and children with suspected intracranial injury must undergo cranial computed tomography (CT), magnetic resonance imaging (MRI), or both.<sup>21</sup> Screening-imaging for AHT is also recommended for infants with facial injury, unexplained fracture(s), or any injury suspected of being inflicted.<sup>23</sup>
- Skeletal survey: A skeletal survey is indicated in any child younger than 2 years with suspicious or unexplained traumatic injuries, including cases of concern for AHT.<sup>24</sup> The skeletal survey should be repeated in 2 weeks, as it may identify additional fractures or clarify tentative findings when abuse is suspected.<sup>25</sup>

Complete and accurate evaluation and management of patients with suspected AHT requires a multidisciplinary approach. This includes consulting subspecialists in child abuse pediatrics, radiology, ophthalmology, neurosurgery, neurology, pediatric trauma, and other fields when necessary. When available, a child abuse pediatrician will assist in ensuring the completeness and accuracy of the evaluation and diagnosis. Once AHT is suspected, health care providers are mandated to report their suspicions to Child Welfare authorities.

## **DIAGNOSTIC SIGNIFICANCE**

AHT is the most common cause of morbidity and mortality in physically abused infants. The diagnosis of AHT is based on history, examination, imaging, and laboratory studies. The AHT diagnosis has tremendous clinical significance. When compared to accidental head injuries, AHT has significantly higher mortality rates, longer hospital stays, and higher hospital charges.<sup>5,23</sup>

AHT may result in permanent neurologic consequences, requiring lifelong treatment and care.<sup>26</sup> These consequences include:

- Developmental disability
- Static encephalopathy
- Cortical blindness
- Cerebral palsy
- Seizure disorder
- Learning disabilities

The diagnosis of AHT also has legal and psychosocial implications related to removal of children from the home and prosecution of family members and caregivers.

## **RELATED CONDITIONS**

Common injuries associated with AHT include retinal hemorrhages, skeletal injuries, soft tissue injury, cervical spine and thoracoabdominal injuries.<sup>27</sup> Patients with AHT should be closely monitored to assess for deterioration in their neurological status. Young infants and those with altered mental status may have subtle but progressive symptoms due to associated injuries, especially intra-abdominal injuries, and should be serially examined.

## **POTENTIAL MIMICS**

Differentiating most cases of AHT from other diseases presenting similar manifestations requires a detailed history, physical examination, and imaging and laboratory studies. Conditions commonly mistaken for AHT are discussed in more detail in the subsequent chapters of this atlas. The following are conditions commonly considered in the differential diagnosis of AHT:

- Accidental head trauma
- Coagulation disorders
- Metabolic and genetic diseases
- Infectious diseases

- Congenital malformations
- Birth-related trauma
- Anoxic injury, eg, suffocation, strangulation, and asphyxia

AHT is a diagnosis that requires a comprehensive evaluation conducted by a multidisciplinary team of professionals. It is essential that a patient is evaluated thoroughly so that the appropriate diagnosis is made. It is also vital that more subtle cases are not missed, and abuse is considered in the differential diagnosis of infants presenting with nonspecific symptoms. The following chapters will explain in more detail the diagnostic approach, differential diagnosis, associated injuries, management, and outcomes of AHT.

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*SECTION II*

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**INTRACRANIAL INJURIES  
WITH ASSOCIATED  
BLEEDING**

---

# EPIDURAL HEMATOMA

Megan Leston, MD

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## COMMON PRESENTATIONS

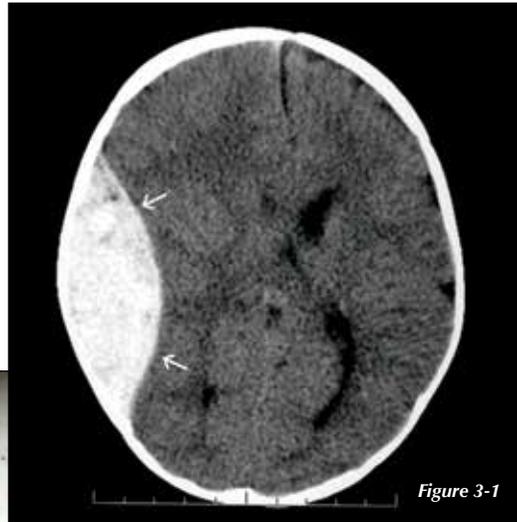
Epidural hematoma (EDH), also referred to as extradural hematoma, is a collection of blood in the space between the dura mater and the overlying skull (**Figure 3-1**). EDH is almost exclusively caused by trauma and is a relatively rare complication of head injury in children.<sup>1-3</sup> Epidural hematoma is more likely to be associated with accidental injury than abusive head trauma (**Figures 3-2 and 3-3**).<sup>4</sup> The most common cause of EDH is accidental injury, particularly falls.<sup>1,2,5-10</sup> EDH is potentially life-threatening, and prompt diagnosis and treatment are important.

## FEATURES

Depending on the severity of the lesion, signs and symptoms of EDH can be vague and nonspecific or can demonstrate more obvious signs of neurologic compromise. Compared to adults with EDH, infants and children often have atypical presentations and, therefore, are at risk for adverse outcomes due to delays in diagnosis.<sup>2,11</sup> Fussiness, irritability, and vomiting are subtle initial signs in infants with EDH.<sup>2,5</sup> Additionally, patients can present with common general head injury symptoms, such as lethargy, headache, or seizure. Some common historical clues that prompt clinicians to suspect EDH include history of a lucid interval, a fall from a significant height, motor vehicle collision, or head injury in a child with a preexisting bleeding disorder.

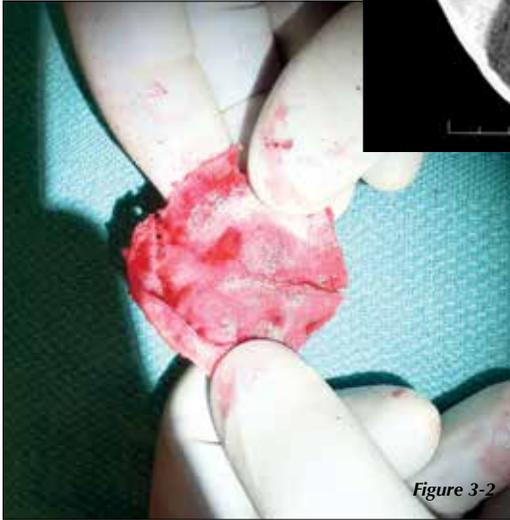
Classically, a lucid interval is associated with EDH. Brief decreased levels of consciousness followed by a return to normal consciousness for several hours characterize lucid intervals. Subsequently, patients rapidly deteriorate due to accumulation of blood in the epidural space, resulting in increased intracranial pressure. However, a history of a lucid interval is inconsistently reported in infants and children with EDH; therefore, the absence of a lucid interval does not exclude EDH.<sup>2,7,10</sup>

In patients with EDH, the physical exam alone may not provide clues to the source of the underlying injury. Cephalhematoma is a common physical finding associated with EDH, particularly in



**Figure 3-1**

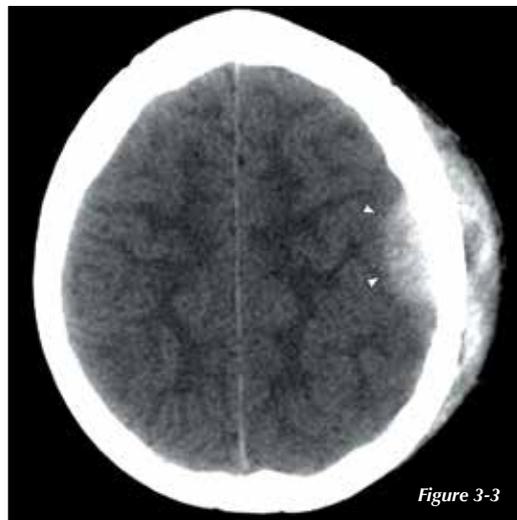
**Figure 3-1.** Axial CT of the head demonstrates right frontal epidural hematoma with mass effect and mid-line shift to the left side.



**Figure 3-2**

**Figure 3-2.** The child required emergent neurosurgical intervention to evacuate the space occupying epidural hematoma. Intraoperatively, he was found to have a linear skull fracture that was overlying the hematoma. (Courtesy Bermans J. Iskandar, MD.)

**Figure 3-3.** Epidural hematoma in a 4 year old who fell out of a wagon. Axial CT image high over the cerebral convexities demonstrates a biconvex, fairly well-defined high-attenuation acute epidural hematoma adjacent to the high left cerebral hemisphere (arrows). There is extensive extracranial soft tissue swelling.



**Figure 3-3**

infants; however, it is not specific to EDH and can be seen with other contact head injuries. A bulging or tense fontanelle can also be found on exam of infants with EDH due to the accumulation of blood within the epidural space. Another physical finding associated with accumulation of epidural hemorrhage is pallor due to anemia.<sup>2,4,7</sup> Previous studies have demonstrated that the presence of pallor and anemia can be strong indicators of EDH.<sup>5,7</sup> Additionally, altered mental status should alert clinicians to neurologic conditions and prompt further evaluation for intracranial injury. Late ominous findings in EDH include bradycardia, hypertension, respiratory depression, pupillary changes, hemiparesis, or hemiplegia. These findings are associated with rapid deterioration and poor outcomes despite immediate rapid surgical intervention.

#### SUBTYPES

In EDHs, the source of bleeding is related to vascular injury and can be characterized as arterial or venous in origin. Arterial bleeding is generally due to meningeal artery injury. Venous bleeding can be due to overlying skull fractures or dural sinus tears. Arterial bleeding is associated with rapid accumulation of blood and is more likely to require surgical intervention. Patients with arterial bleeding may be in shock from acute blood loss. Typically, EDH from arterial bleeding is associated with a lucid interval, although patients may or may not have a history of loss of consciousness.<sup>12</sup> In contrast to arterial bleeding, venous bleeding results in a slower accumulation of blood under low pressure, and therefore, presenting symptoms can be vague or delayed.

The majority of EDHs are supratentorial in location.<sup>7</sup> However, posterior fossa EDHs, although rare, can have significant morbidity and mortality. Posterior fossa EDHs are diagnostic challenges for clinicians. Often, the symptoms are vague or delayed, and patients remain undiagnosed, initially. Initial symptoms include vomiting, headache, and loss of consciousness, and patients can also present subacutely with symptom onset several days after the trauma.<sup>7,13</sup> In posterior fossa EDHs, a fall onto the occipital area of the head is the most common mechanism of injury and frequently results in an occipital skull fracture. Due to the location of the trauma, a tear in the dural sinus can result in venous hemorrhaging. In contrast to arterial hemorrhaging seen in many EDHs, venous hemorrhaging is slower and contributes to the delayed onset of symptoms. Worrisome characteristics of a patient with posterior fossa EDHs can include a sudden decline in the neurological status of the child or cardiopulmonary arrest.<sup>13</sup> A delay in diagnosis and treatment can have detrimental effects for the patient and can result in death.

### Case Study 3-1.

A 4-month-old male child presented to the emergency department after his mother reported he “did not appear right” and was less responsive than usual. The mother reports that several hours earlier, she had left the infant propped up sitting in the corner of the couch in the living room when she went into the kitchen to prepare a bottle. She then heard an unusual cry. The mother went into the room and noticed that her infant was laying on the floor; she suspected that her 4-year-old daughter had dropped him. The floor was concrete with a thin industrial type carpet covering.

The infant was crying but consolable with no visible head injury. During the next 4 hours, he would cry intermittently. A friend then came and thought that the baby’s left eye looked abnormal and puffy, and that the child was having difficulty opening this eye. He was then taken to the emergency department.

The other verbal children in the home were forensically interviewed and stated that the 4-year-old attempted to pick up the baby from the couch and subsequently dropped him on the hard flooring.

## SUGGESTED TREATMENT

Head computerized tomography (CT) is the diagnostic test of choice because of its accessibility, speed in performing imaging, and ability to delineate the extent of hemorrhage. The appearance of EDH is characteristically described as a lens-shaped or biconvex, hyperdense collection of blood that can result in mass effect with midline shift. Generally, an EDH does not cross suture lines (**Figures 3-4**).



Figure 3-4-a

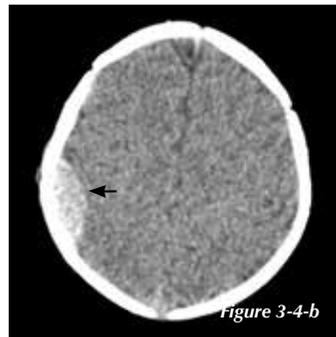


Figure 3-4-b

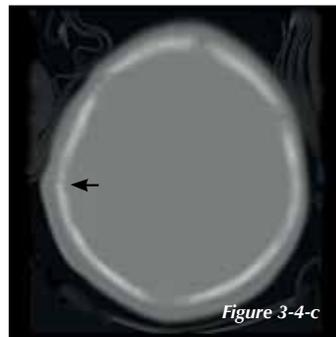


Figure 3-4-c

**Figures 3-4-a through c.** Axial noncontrast enhanced CT images of the head in a 21-day-old female demonstrate an echogenic lenticular-shaped extraaxial fluid collection in the right frontoparietal region, consistent with an epidural hematoma. Axial and 3D reformatted images of the skull demonstrate a nondisplaced fracture overlying the fluid collection. (Courtesy of Kara G. Gill, MD.)

Early neurosurgical consultation is critical in selecting treatment for patients with EDH. Depending on the neurological status of the patient, head CT findings, and possible additional injuries, operative intervention may or may not be indicated. Operative management is often preferred over observation if a patient has decreased mental status, neurologic findings on physical exam, signs of increased intracranial pressure, or CT with findings of mass effect. Operative treatment consists of craniotomy with evacuation of the EDH and control of the bleeding source.<sup>12</sup>

Nonoperative management is typically reserved for patients without neurologic signs on physical exam and without concerning findings, such as large size of the EDH or mass effect, on head CT. When observing EDH, patients are closely monitored, and a follow-up head CT is typically performed within 6 to 12 hours.<sup>12</sup> Serial head CT scans can be helpful in the ongoing monitoring of size of the EDH and in assessing mass effect.

Younger children typically have better outcomes, including decreased morbidity and mortality, than older children and adults with EDH.<sup>2,3,7</sup> Previous studies have demonstrated poorer clinical outcomes associated with low Glasgow Coma Scale (GCS) at presentation, additional intracranial injury, and pupillary changes.<sup>3,7</sup> Prompt diagnosis and early neurosurgical intervention are associated with improved clinical outcomes.

## DIAGNOSTIC SIGNIFICANCE

The most common cause of EDH is accidental injury, particularly falls.<sup>1,2,5-10</sup> However, nonaccidental trauma must be considered in children with intracranial bleeding, particularly in infants and young children. Merten and colleagues found 2 of 47 physically abused children had epidural hematomas evident on CT scan.<sup>14</sup> Shugerman et al retrospectively studied 93 children less than 3 years of age with head injury and found that 34 (37%) had EDH. Of the 34, 2 (6%) were determined to have been abused.<sup>9</sup> Additional studies have confirmed Shugerman's findings.<sup>10,15</sup> Ewing-Cobbs et al prospectively studied head CT and/or magnetic resonance imaging (MRI) findings of 60 children, ages 1 month to 6 years and found that 6 children had EDH. In all 6 of these children, the injuries were attributed to noninflicted mechanisms.<sup>15</sup> Wells et al conducted a retrospective study of 293 children less than 3 years of age with intracranial hemorrhage during a 10-year period. In this study, EDH occurred in 80 patients (27%) and was associated with non-inflicted injuries in 62 patients (78%) and with inflicted injuries in 14 patients (18%). Most of the EDHs in this study were small and not associated with additional injuries.<sup>10</sup> These studies support the finding that EDH is rare in inflicted injury, occurring in 0% to 18%

of all children with EDH. However, EDH as a result of inflicted trauma does occur. As with other intracranial injuries caused by abuse, children with inflicted EDH tend to be younger than 3.

Diagnosing inflicted injury can be difficult and is complicated by multiple factors. Child abuse should be considered a possible cause of trauma in cases with no clear accidental history or inconsistent injury mechanisms for degree of injury or developmental status. Also, if a child presents with multiple injuries, such as bruising, fractures, abdominal injury, retinal hemorrhages, or other intracranial hemorrhage, inflicted injury must be considered. When child abuse is suspected, appropriate medical evaluation, which should include a skeletal survey in children less than 2 years of age, is indicated. Ophthalmologic exam is recommended for any child with EDH suspicious for nonaccidental injury; however, retinal hemorrhages have been described in the setting of accidental EDH.

A retrospective study by Forbes et al<sup>16</sup> reviewed children under 3 years of age with EDH and with documented dilated ophthalmologic examinations from 1998-2002. The study sample was comprised of 9 patients, 5 of whom had retinal hemorrhages. All 5 patients were evaluated by the institutional child protection team who concluded that all cases were consistent with accidental injury. The retinal hemorrhages in all the cases were few in number, superficial, and limited to the posterior pole; such hemorrhages are distinct from the severe retinal hemorrhages classically seen in abusive head trauma.<sup>16</sup>

In addition, when evaluating for child physical abuse, brain MRI can be useful to better characterize the head injury and assist with timing the injury. Liver transaminases are recommended to screen for occult abdominal trauma in children less than 5 years of age in whom abuse is suspected. Additional laboratory evaluation to screen for underlying medical conditions, such as hematologic evaluation, should be performed as indicated by risk factors in the past medical and family histories. If child abuse is suspected, clinicians should report cases to child protective services as required by their local government agencies.

## **RELATED CONDITIONS**

Skull fractures can be indications of intracranial injury, including EDH.<sup>17</sup> The reported cooccurrence of skull fractures with EDH ranges from 50% to 99%.<sup>2,3,5,10,11</sup> Therefore, identification of a skull fracture is a risk factor for EDH, and additional diagnostic evaluation may be warranted; however, the absence of a skull fracture does not exclude a diagnosis of EDH or other intracranial injury.<sup>5,17</sup>

Retinal hemorrhages associated with EDH have been described.<sup>16</sup> The presence of retinal hemorrhages can have dramatic impacts when

determining if an injury is consistent with accidental or inflicted injury. The association between retinal hemorrhages and abusive head trauma (AHT) is well described, and the importance of the particular patterns of retinal hemorrhages is critical when considering accidental and inflicted mechanisms of injury.<sup>18-21</sup> However, unlike the pattern of retinal hemorrhages classically associated with AHT (numerous, diffuse, multilayered, and extending to the periphery), the retinal hemorrhages reported with EDH are described as superficial, confined to the posterior pole, and few in number.<sup>16</sup>

## POTENTIAL MIMICS

The diagnosis of EDH relies on radiologic imaging. The characteristic appearance of EDH on head CT, as described previously, helps differentiate EDH from other intracranial bleeding, such as subdural hemorrhage and subarachnoid hemorrhage. MRI can also be helpful to further define the extraaxial fluid spaces and determine the location of collections.

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*Appendix, boxes, figures and tables are indicated by a, b, f, and t respectively*

*To save space in the index, the following abbreviations have been used:*

AHT = abusive head trauma

CSDH = chronic subdural hematoma

EDH = epidural hematoma

PTH = posttraumatic hydrocephalus

SAH = subarachnoid hemorrhage

SDG = subdural hygroma

SDH = subdural hemorrhage

SGH = subgaleal hemorrhages

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